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GROWING Points

Department of Environmental Horticulture • University of California, Davis

California Cut Roses: Production and Preservation - Part I

As both professional and hobbyist gardeners will attest, coastal California is a prime location for horticulture. For the 80 or so commercial cut rose growers in the state, mild temperatures together with a long growing season provide an advantage in the quest to produce high-quality cut roses at a marketable price. Recent USDA statistics bear this out: According to the Floriculture Crops Summary for 1997, California growers produced 70% of the cut roses grown nationwide.

Driven largely by seasonal demand, the US market for cut roses presents a challenge to growers. Meeting the Valentine's Day demand, for example, requires that they deliver their product within a 5-day window of time. To meet this challenge, growth must be timed precisely through careful manipulation of heating and cooling–a task that can't be accomplished in the field. For this reason, most cut roses are grown in greenhouses.

In order to take maximum advantage of available space, greenhouses are planted intensively. In a typical commercial-scale production scheme, rose plants are planted in hedgerows. Types of growing media vary. Traditional media are native soil and potting mixes. Some growers are switching to hydroponic systems that utilize coconut coir, clay pellets, or rockwool.

Harvested roses are ready for sorting and grading.

Rose varieties grown for the cut flower market are different from those grown for landscape use. Several considerations determine which varieties are grown: abundance of flowers, stem length, bud shape, vase life, disease resistance, and color. Based on these criteria, some of the current most widely grown varieties are Kardinal (red), Bianca and Lady Liberty (white), Dolores (pink), Emblem (yellow), Osiania (peach), and Fire and Ice and Ambiance (bicolor). Desert tone varieties such as Sensation (apricot) and Sahara (tan) are increasing in popularity.

For all varieties, optimum production depends on an adequate supply of water and fertilizer. Through a system called *fertigation*, given volumes of fertilizer are injected into irrigation water and delivered to plants via water lines and emitters. The fertilizer typically contains nitrogen, potassium and phosphorus, and may also contain other nutrients that are lacking in the water or soil. The goal is to supply the best balance of essential elements at all times.

At harvest time, flowers are cut just above the first or second 5-leaflet leaf, which is left for photosynthesis and the development of a new stem. Throughout the growing season, the plants get progressively taller. Then, during summer when prices are down, they are pruned back.

The cut roses are stored in coolers in buckets of water and then graded and sorted according to stem length, foliage and flower quality, and stage of bud development. They are then shipped in refrigerated trucks or by air to florists and flower vendors.

Like landscape rose plants, greenhouse roses require pest control. Because pesticide use can be economically and environmentally costly, many growers currently employ components of integrated pest management (IPM) in their operations. Techniques such as biological control, habitat manipulation, modification of cultural practices and use of resistant varieties reduce the need for pesticide application. While few production operations incorporate all aspects of IPM, increasing numbers of growers are implementing various components of this ecosystem-based strategy for pest control.

UC Davis floriculture faculty and specialists conduct ongoing research to provide information on new production and preservation techniques. Information from some of their projects will be featured in the summer and fall issues of Growing Points. ***—The Editor***

In This Issue...

To Pinch or Bend? Manipulating Cut Rose Quantity and Quality in Greenhouse Production

By Heiner Lieth, Professor of Environmental Horticulture and Cooperative Extension Specialist, UC Davis

Over the years, breeders have developed rose varieties separately for gardens and commercial cut flower production. Garden roses are selected to do well under conditions that commonly occur in gardens and to provide a showy display that meets the needs and desires of the gardener. Cut rose varieties, on the other hand, are selected for their ability to produce a large number of high quality flowers per unit area of greenhouse space per year.

Conventional Method

Bent Canopy Method

The Conventional Production Method

Cut rose production methods have been fairly standard for many years. The common strategy is to produce a large number of high-quality flowering rose stems (i.e., a flush of flowers) to be available for sale at desired times. Targeting these desired times involves a cycle of *pinching* and *harvesting*. Pinching is the process of removing the upper section of a growing shoot (the uppermost leaves and bud). It effectively sacrifices a growing shoot in favor of a new one that will be available for a desired target date. Harvesting is the removal of a rose shoot that is close to flower opening.

The action of pinching or harvesting has the effect that within a few days a new shoot begins to grow in the leaf axils (area where leaf springs from stem) of the uppermost remaining leaves. It will then take 4 to 6 weeks until the resulting shoots are ready for harvest.

The goal is to get new shoots to start growing at just the right time and to then control the greenhouse environment so as to bring that flush of flowers to flowering in time for the target date. Growers do this by identifying the date that they wish to target and then counting backwards the number of days that they know are required to produce an acceptable flowering shoot under normal greenhouse conditions. The rate of shoot development is then controlled by regulating the air temperature: The higher the temperature, the higher the development rate. Temperature must be manipulated with care, since higher temperatures can result in lower flower quality.

To obtain a large number of shoots in time for a target date requires that many plants receive a pinch or harvest simultaneously. Thus, in conventional rose production, there is a cycle of harvesting and pinching that has been pretty well established for many years and growers know the methods that are needed to achieve this pattern.

The Bent Canopy Production Method

In recent years, new production techniques have been added to these methods. One of the most interesting of these is the bending of undesirable stems. With this method, rose stems are bent in such a way that all but the bottom two leaves on the stem are bent down (See Figure 1, page 4). The effect of this is that the stem stops elongating and the buds in the leaf axils at the base of the shoot (below the bend) begin to grow, while those on the bent portion are inhibited. Generally, the new shoots have the potential to be much stronger because they have the carbohydrate supply of the bent shoot providing carbohydrates for growth.

How Does It Work?

While the physiological changes that occur when a rose shoot is bent are not well understood, the most likely explanation for what we observe is that they result from a hormonal reaction. When a stem grows upright without any bending, the growing bud is producing auxins (plant growth hormones) which migrate down the stem. The concentration throughout the stem is such that it prevents buds below the growing point from

Rose Crop Modeling To Analyze Production Techniques

At UC Davis, we are working on a multifaceted computer-modeling project that will identify key elements of rose production. The intent is to be able to analyze new production techniques such as canopy bending to determine what impact they might have on profit.

This project starts with basic elements of rose plant physiology (leaf photosynthesis, shoot growth, respiration, etc) and uses mathematical models to calculate the rates of these processes for individual rose shoots. For example, the photosynthetic response to light is represented by an equation as graphed in Fig 1. The model shows leaf photosynthesis as a “saturation response” with a maximum rate of photosynthesis that is dictated by the leaf age and leaf temperature (Figs 2 and 3).

All these elements combined form the rose leaf photosynthesis model. With this we can calculate how much biomass each rose shoot can produce on any given day in the greenhouse. The next step in our research was to develop a model for simulating a growing rose shoot. We accomplished this by combining the models for the various processes to simulate the amount of biomass in the leaves, stem and flower using the greenhouse climate measurements as the basis for the calculations. Thus we can calculate how individual shoots in a rose canopy grow.

The next step, one that is currently under development, is to simulate a conventional hedge system by tracking layers of stems and foliage in the canopy and identifying groups of stems of similar age and position in the canopy. We will then use the shoot growth model to predict what happens to each shoot.

Simulating a system involving bent stems is very different because the only stems and foliage that grow up are shoots that will be harvested; the rest of the stems and foliage are below these growing shoots. We do, however expect that the basic procedure for doing the simulation will be the same.

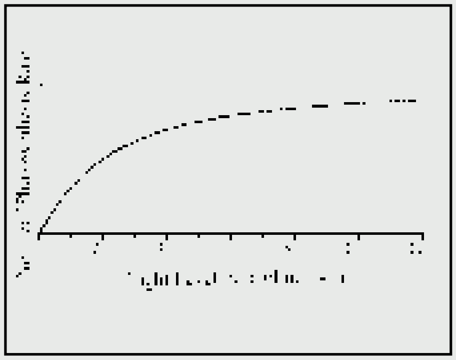

Figure 1. *Light response curve*

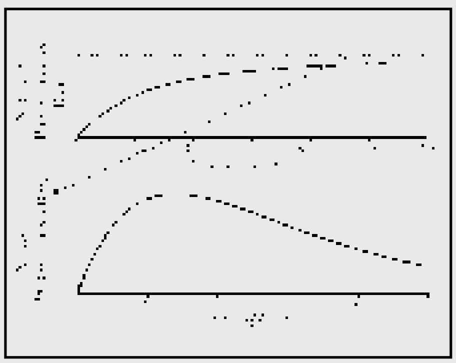

Figure 2. *Photosynthetic response to leaf age*

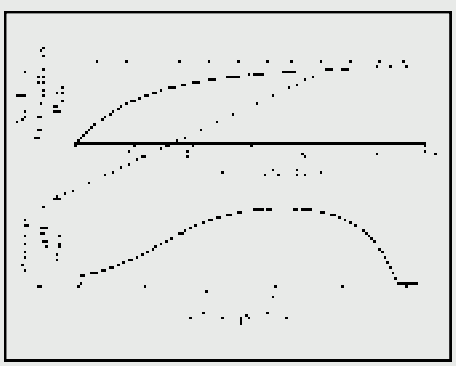

Figure 3. *Photosynthetic response to leaf temperature*

By simulating these systems we expect to be able to calculate how much biomass can be produced in each system. This allows us to calculate potential production levels in each system under a variety of circumstances.

It will be a number of years before we have the final model in place. But, in the meantime, we are already reaping benefits from this research. For example, the test area in which we are carrying out our experiments allows us to track production under conventional and bent-canopy conditions. So far we have already seen that the *quality* of the production on plants involved in bending is significantly better, but the *quantity* is lower. In other words, the new production method results in better quality but you get fewer flowers. We have also been able to provide some insight for growers as to how leaf age affects the usefulness of particular stem, particularly in bent canopies where leaves are generally much older than on the growing stems. We have also been able to carry out simulations as to the leaf area of rose canopies and to show how various levels are more optimal than other levels.

Many other specific questions have arisen and our rose crop modeling project is designed to answer these. It is hoped that, with a mathematical model for rose crop production, we will be able to identify the optimal way to produce roses using any conceivable production method.

This work is supported by the California Cut Flower Commission and the Joseph Hill Foundation.

–Heiner Lieth

growing. If a growing shoot is pinched, this source of auxin is removed so that the buds break dormancy and start to grow. Once these grow, they, in turn, produce auxins which then inhibit slower-breaking buds below and prevent buds on the newly growing stem itself from breaking dormancy.

If, instead of pinching, the shoot is bent down so that the top part of the shoot is below the point of bending, any auxin in the bent part of the stem accumulates in the tip. With the resulting elevated auxin levels in the bent stem, elongation is inhibited so that little or no further growth occurs. On the other side of the bend there is no source of auxin so that the buds there are no longer inhibited from breaking or elongating. Thus, they effectively behave as if a pinch had occurred. It is postulated that, since the bent portion of the stem is unable to grow, any carbohydrates produced there through photosynthesis are used by the plant at the sites on the plant where growth can occur (i.e. the newly growing shoots). This explains why the new buds close to this carbohydrate source are generally larger. While this explanation of the physiology involved in canopy bending matches observations to date, it should be noted that it is a theory that can only be verified by research.

"Stems grown with the bending method have the potential to be much stronger than those grown conventionally."

The effects of canopy bending can also be analyzed from the crop management perspective. When observing rose crops planted in a traditional hedge production scheme, a lot of ground surface is visible. With bent roses, on the other hand, virtually no ground is visible because the bent shoots cover the aisle. It follows that more light is intercepted by the foliage on the bent stems and that, therefore, much more of the light entering the greenhouse is captured by the plants and converted into carbohydrates for building biomass (i.e., rose shoots).

Another observation frequently made about canopy bending is that it produces more flowering stems, many of which are of the higher quality grades. This, however, may be an optical illusion—the bent-away plant material of a bent canopy is weak and not harvestable, so that all harvestable shoots are visible. In a conventional hedge, many harvestable shoots are hidden from view. When counts are made, there are generally fewer harvestable stems in the bent production system, although more of these are of the higher grades.

Will quality make up for quantity?

Rose quality is measured in stem length: Stems of 16 to 18 inches in length are given the lowest grade, while those of 26 to 28 inches in length receive the highest grade. After harvest, flowers are sorted into 4 or 5 grades and bunched separately by variety. The higher grades always sell for higher prices.

The problem that we have seen in our trials at UC Davis is that the extra return for the higher grades achieved with bending is only enough to cover the production loss. It does not provide a sizable enough return to warrant using the bending method. So it appears that switching to this method, while not necessarily detrimental, does not provide an automatic economic boost.

There are, however, other benefits to the new method that may make it attractive to growers. For example, while bending requires more labor initially, harvesting is simplified because the harvestable shoots are located together on the plant. Having the harvestable shoots grouped together, away from the plant material that is not harvested (i.e., the bent canopy), may also allow growers to use more targeted pest control practices, possibly reducing production costs further. No quantitative analysis of such benefits has been made, so it is not possible to calculate a comparison, but there is anecdotal evidence that these savings can be substantial.

For researchers, there are a lot of unknowns related to bending. For example, most of the time a physical kink results when a stem is bent; sometimes there is even a crack or other open wound. We don't yet know if this is a problem. Does the nature of the bend affect the movement of carbohydrates from the leaves on the bent stem to the new growing stems? There is also the question of whether one should remove the flower bud from a shoot when bending it.

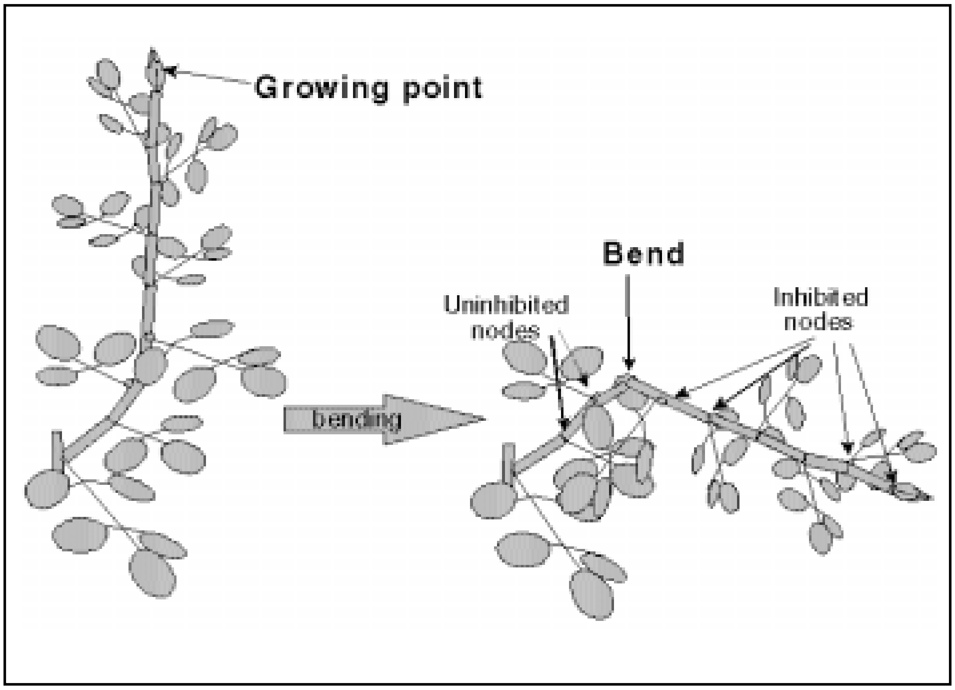

Figure 1. *A shoot is bent over so that its growing bud is below the leaves on the stem. It is believed that this bend blocks the supply of auxin produced at the growing point that inhibits lower bud development in a normal, upright shoot.*

There is currently no clear-cut answer for growers as to which method is best. Each must weight the pros and cons for him/herself. In commercial rose production, the greenhouse is optimized for rose production. In our research greenhouses, we generally cannot do the same level of optimization (although we can get close). Thus, commercial growers may be able to push production levels in such a way that a small margin becomes worthwhile. Growers can assess profitability by tracking production separately under the different production methods and comparing profits from sales figures.

Improved Nitrogen Management for Greenhouse Roses

By Richard Evans, Cooperative Extension Specialist

The modern rose cultivars used for cut flowers share a common trait: perpetual flowering. For high flower yields, commercial rose growers employ intensive production practices that result in high fertilizer and water use. The predominant method of fertilizing commercially grown roses is fertigation, the continuous liquid feed of inorganic fertilizers.

In most instances, nitrogen is supplied as nitrate. The nitrogen concentration in the irrigation water is usually very high, between 200-250 parts per million (ppm). By following the practices recommended by the rose industry, growers apply nitrogen at an annual rate equivalent to about 3-4 tons per acre. These amounts are excessive, even for a fast-growing crop such as roses. A rose grower could expect that even the highest possible yields of harvested flowers would contain less than 20% of the applied nitrogen. Most of the remaining applied nitrogen would be lost below the root zone.

Impact of Excessive Fertilization. The impact of excessive fertilizer applications is evident from the results of soil sampling in commercial rose greenhouses. We measured the concentration of nitrogen as nitrate in the soil solution beneath several California greenhouses. Typical values near the soil surface ranged from 250-900 ppm (Figure 1). Since these values exceeded the concentrations of nitrogen in the liquid feed, it is evident that nitrogen had been applied at rates that far exceeded plant needs. As much as a ton of dissolved nitrogen per acre was present in the root zone at any given time. The concentration in the soil solution below the root zone (and therefore unavailable to the plants) was between 150-500 ppm. This leached nitrogen is important because, depending on soil conditions and water movement through the soil, it could contaminate drinking water supplies. High levels of nitrate in ground water pose a serious health risk to humans who consume it, particularly babies, because the conversion of nitrate to nitrite in the stomach may lead to the impairment of the oxygen-carrying capacity of the blood (methemoglobinemia).

Nitrogen Studies. Because of our concern about nitrogen leaching, we studied the nitrogen requirements of roses and methods by which nitrogen fertilizer uptake could be made more efficient. In a study funded by the American Floral Endowment and Roses, Incorporated, we measured nitrogen leaching losses over the course of a year from roses that received different leaching rates and nitrogen concentrations. We found that roses irrigated at a leaching fraction of 25% (that is, only three-fourths of the applied water was transpired by the plants or evaporated from the soil surface) with liquid feeds containing 77, 154, or 231 ppm nitrogen had similar yields, and that nitrogen leaching losses were reduced substantially by lowering the concentration of applied nitrogen. However, even the most conservative rate of addition resulted in the loss to leaching of over 20% of the applied nitrogen, indicating that there is room for further economy.

Subsequent research has shown that nitrogen uptake by roses is episodic. Nitrogen uptake is linked to shoot development, but periods during which the rate of shoot growth is high do not correspond to those during which nitrogen uptake is high. Moreover, following flower harvest, the rate of nitrogen uptake by the plant remains high for several days, although there is no new shoot growth during this time. Nitrogen uptake then declines during the period when buds of new flower shoots begin to break, and uptake is lowest when the shoot is growing most rapidly. Rose plants use old canes and leaves as nitrogen "warehouses" that supply nitrogen as needed to meet the requirements of growing shoots, then replenish the stores of nitrogen when shoots stop growing. The timing of nitrogen application, therefore, may be critical in relation to plant nitrogen demand and management of leaching losses. By matching fertilizer applications to the plant demand for nitrogen, growers could achieve more efficient use of applied nitrogen.

Other Options for Improving Fertilizer Use Efficiency. In addition to matching fertilizer application to time of plant demand for nitrogen, growers have other options for improving fertilizer use efficiency. These include changing the form of nitrogen applied and increasing the interval between applications.

Most recommendations for nitrogen fertilization of roses rely predominantly on nitrate. The common view is that fertilizing with ammonium as the main source of nitrogen can result in ammonium toxicity to the plant. In terms of reducing leaching losses, however, ammonium would be the ideal source of nitrogen because rose plants absorb it more rapidly than nitrate and it does not leach as

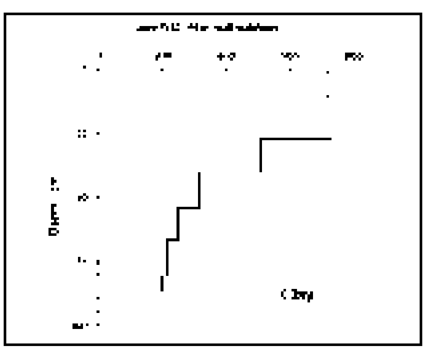

Figure 1. *Nitrogen present as nitrate in solution in the profile of a clay soil taken from a commercial rose greenhouse.*

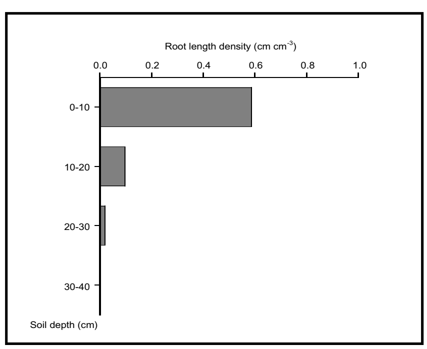

Figure 2. *Root distribution in the soil profile of a commercial rose greenhouse.*

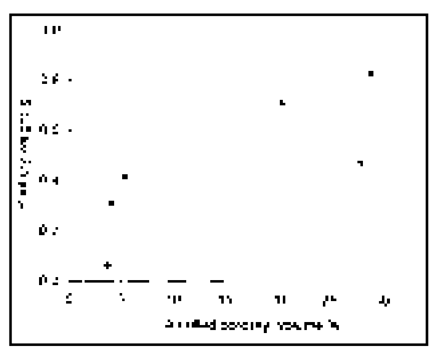

Figure 3. *Effect of air-filled porosity of the growing medium on the yield of new rose roots after 2 months of growth.*

readily in the soil. We have found that roses can be grown satisfactorily with ammonium as the sole source of nitrogen, with no signs of ammonium toxicity, if the soil pH remains stable. Thus, growers could reasonably use it as the main source of nitrogen in conjunction with other modifications in growing practices that allow for control of pH. With either nitrate or ammonium as the nitrogen source, rose plants could be stimulated to increase the rate of fertilizer uptake by fertilizing less frequently. We found that the rate of nitrogen uptake was doubled after "starving" plants of nitrogen for four or more days, and that this enhanced rate of uptake lasted for four days after restoring normal nitrogen levels to the root zone. Intermittent fertilization with nitrogen could reduce nitrogen leaching losses because substantial amounts of nitrogen would be in the root zone, where it is susceptible to leaching, only half the time.

Nitrogen Recommendation. Based on this work, and on other studies we have done to measure nitrogen and water requirements of roses, we can state that roses could be grown with an average nitrogen concentration in the liquid feed of 80 ppm, with no decrease in flower yields. There is a caveat, however, which is that the root system of most commercial roses is extremely small and shallow (Figure 2). A grower whose plants have such a limited root distribution and surface area cannot easily change either fertilizer or irrigation practices. We have some evidence that the root system can be encouraged to increase in size and depth by improving soil aeration (Figure 3). Improved soil aeration can be achieved by management practices that promote good soil structure (such as incorporating organic matter and not tilling when soil is wet) and by reducing irrigation frequency to allow for drainage between irrigations.

In future work, we hope to assess the characteristics of several rose rootstocks, in terms of both nitrogen uptake and tolerance of low aeration.

For Your Information:

Cabrera, R.I., R.Y. Evans, and J.L. Paul. 1993. *Leaching losses of N from container-grown roses.* Scientia Horticulturae 53:333-345.

Cabrera, R.I., R.Y. Evans, and J.L. Paul. 1995a. *Cyclic nitrogen uptake by greenhouse roses.* Scientia Horticulturae 63:57-66.

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News From the Ex(tension) Files

By Linda Dodge

Mrs. L. R. of Sacramento asks:

My Modesto ash looks terrible this spring. It tries to put out new leaves but they just fall off. What's happening and will I lose the tree?

This is yet another situation that can be blamed on El Niño. From the symptoms you describe, it sounds like your Modesto ash is suffering from the fungus disease, anthracnose. The cool, wet spring that we experienced provided perfect conditions for the proliferation of the several fungus species responsible for infecting some of our most popular landscape trees. The fungi attack new shoots and expanding leaves, growing rapidly from spores under moist conditions. Infected leaves may become curled and distorted or drop from the tree entirely. As the tree produces more leaves, the cycle may repeat itself if wet weather persists. When dry conditions finally prevail, the fungus cannot grow and the tree will produce new, undamaged leaves. This spring, anthracnose took an unusually heavy toll on trees such as the Modesto ash, California sycamore and some cultivars of the London plane tree. Parts of Sacramento looked like winter would never end and streams along Highways 156 and 152 where California sycamores are abundant looked like January in May.

Control of anthracnose on susceptible trees is difficult. The fungicides chlorothalonil (protective) and thiophanate-methyl (systemic) provide some control on Modesto ash but are ineffective for other host species. These materials must be applied on all new growth as buds begin to open in the spring. Repeat applications every two weeks may be necessary if wet weather persists. Cultural practices, such as disposal of fallen leaves and pruning of infected branches, can be helpful in reducing the amount of overwintering fungus spores available for infection next spring. For new plantings, the best defense against anthracnose is the use of resistant species and cultivars. The 'Bloodgood' cultivar of London plane tree and the ash varieties 'Moraine' and 'Raywood' are more resistant to anthracnose infection.

Mr. S. B. of Stockton asks:

My planting of ivy has become infested with dodder. It was recommended that I remove all the ivy. Is there some other control measure available?

Dodder is an unusual parasitic weed that most often infests agricultural crops like alfalfa but, on occasion, can be a pest in ornamental plantings. There are several species of dodder, each with a range of preferred host plants. When a dodder seed germinates, it sends out a thin yellowish stem, sensitive to touch, that twines around the first plant part it contacts. If the host is compatible, the growing dodder plant produces root-like haustoria that penetrate the host plant and begin extracting water and nutrients. As the dodder plant increases in size, forming a tangled mat of orange stringy stems, the host plant is weakened. The dodder plant becomes completely dependent on the host and loses contact with the soil. When the dodder plant matures, it produces many seeds that can remain dormant in the soil for up to five years. In addition, dodder often harbors disease organisms and can be a vector for several of the yellows diseases.

These circumstances of the life cycle of dodder make control a difficult matter. The best course of action is to remove and destroy all infested plants, especially before the dodder has set seed. The area should then be treated the following spring with a pre-emergent herbicide to kill any germinating dodder seed. A contact herbicide to kill both dodder and its host offers some control of established plants. Mechanical removal of the dodder plants from the host plants is usually not feasible because all traces of dodder must be removed. It looks like those ivy plants are doomed to destruction.

Notes From the Chair...

By Dave Burger

Congratulations to this year's graduates of the Environmental Horticulture and Urban Forestry program. They are: **Kara Barker**, **Giacomo Damonte**, **Aero Acton**, **Alyssa Darnall**, **Johanna Good**, **Richard Griffing**, **Charles Colfax Hughes IV**, **Holly Pichinino**, **Christina Simpson**, and **Kristi Lewis**. **Kara Barker** and **Kristi Lewis** received Departmental Citations in recognition of their outstanding accomplishment in the program.

The International Society of Arboriculture Research Trust Board of Trustees has awarded a Duling Grant of $5,000 to **Paula Peper** of the Western Center for Urban Forest Research and Education. Her study will supply municipal and utility arborists with information on growth rates of the most common street tree species growing in warmer coastal and inner-coastal climates. Data collection for the study will take place on 22 tree species in Modesto, California.

The Teichert Foundation has generously awarded a grant of $9,760.00 to the Department to begin construction of the Urban Forestry courtyard sustainable landscape. Urban Forestry Project Leader **Greg McPherson** expects work to begin this summer with the installation of cisterns and paving.

Design committee members are seeking additional funding to finance completion. For more information on this project, see the winter issue of Growing Points.

Where are they????

Richard Baldwin, who received his MS degree with Roy Sachs in 1975, worked as a farm advisor in Ventura County until his retirement in 1983.

Since that time, he has continued to be involved in the ornamental horticulture field through research and teaching. His long-term project in cooperation with Ventura Community College looks at deciduous fruit varieties that are adapted to the warm Southern California winters. He also teaches horticulture classes at the college.

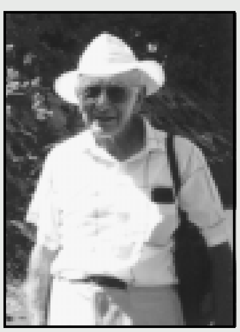
After receiving his MS in Horticulture with Dave Burger in 1984, **Bruce Follansbee** worked for 5 years with a consulting firm on suburban development mitigation projects throughout coastal California. He then returned to UC Davis, earning his Ph.D. in Ecology in 1996.

Currently, he works with the Tillamook Bay National Estuary Project–one of a group of 30 regional restoration projects, nationwide. As a senior scientist, Bruce works with a team performing watershed assessment and analysis that will result in a conservation management plan aimed at reducing the decline of natural resources in Oregon's Tillamook Basin.

After working with Katashi Landscape Nursery in Santa Barbara for a year, **Susan Alvarez** became a registered seed technologist with Ransom Seed Laboratory in Carpinteria, California. She works mainly with California native seeds, noting that there is a flurry of interest right now in acquiring and establishing native plants.

Active in several horticultural organizations, she serves as a regional editor for Seed Technologist Newsletter, a publication of the Society of Commercial Seed Technologists. She also gives talks and participates in workshops related to seed technology.

Susan received her MS in Horticulture with Jim Harding in 1984.



On June 2nd of this year, Daniel Isaac Axelrod passed away, unexpectedly. He had been a memorable part of the human landscape on the Davis campus since 1967, and of the Environmental Horticulture Department for the past dozen years.

"Ax," as he often signed his letters and liked to be called, was a paleoecologist who reconstructed past climates, vegetation types, and entire landscapes from fossil impressions of leaves and stems. His focus was on climate and vegetation change for western North America over the Tertiary period. As Peter Raven, Director of the Missouri Botanical Garden, recently said, he was "the first person who matched modern plant communities with ancient, fossilized ones. He made a fantastic contribution to our knowledge of vegetation change over the last 40 million years."

Ax was a vegetation scientist with a particularly long-term frame of reference, a unique perspective that constantly was apparent in throw-away comments on field trips: "That fir species? It's only been here 12 million years." "Those rocks? They're almost as old as I am." "That forest? It's only been here since the glaciers left.")

Professor Axelrod's work over a span of two-thirds of a century informed several generations of scientists and they, in turn, honored him with numerous awards: medals from the California Academy of Science, the International Paleobotanical Society, the Philadelphia Academy of Science, and the Paleontological Society, and fellowships from the Guggenheim Foundation and the US National Museum. He was also an elected member of the American Academy of Science.

His first career began as a graduate student at UC Berkeley, where he published his first paper in 1934. It continued when he was hired as an Assistant Professor of Geology at UCLA, changed location when he moved to UC Davis in 1967, and "ended" with retirement from the Botany Department in 1976.

His second career began the first day of retirement and ended the day of his passing. During those 22 years he published as many or more papers as he had in his first 30 years. It was during his second career that he received most of his awards, including his selection by UC Davis as the outstanding researcher on campus—probably the only time an emeritus faculty member had been chosen for that honor.

I recall a field trip when he took me and Murray Buell (a recently retired ecologist from Rutgers University who was visiting California at the time) to the northernmost grove of Sierra redwoods. It was a warm July day, so he put the top down on his magnificent white convertible (whose license plates read "PROF AX"). As he drove us through several elevational zones, he talked almost intimately about the landscapes that swept by. At the grove, we discussed the past and present ecology of Sierra redwoods and feasted on a picnic lunch that he had made for us, complete with tablecloth, napkins, picnic basket,
a bottle of good wine, and wine glasses. A great day… a memorable day. I took a picture of Ax carrying my picnic lunch into the woods because this side of crusty Dan Axelrod—

At the entrance to the Department, Amanda Lewis stands near a Nyssa sylvatica (March Sour Gum) tree. The tree was planted in the early 1980s in recognition of Dr. Richard W. Harris, Professor Emeritus, who wrote the commonly accepted authoritative text on arboriculture.

Environmental Horticulture extends an especially colorful welcome these days, due in large part to the volunteer efforts of Amanda Lewis. A post graduate researcher with the Department for four years, she received her BA degree in plant science with a specialty in floriculture in 1994.

Planted two years ago by Jim Harding and a group of volunteers, the garden looked to Amanda like a place where she could "volunteer her time and horticultural skills and give something back to the department."

With the help of former EH student Gail Setka of HortiCorps (a volunteer group that tends special gardens on campus) and departmental staff, she added annuals and perennials to established beds and created a miniature rock pool.

This year, she continues to weed, prune, plant and tend. Thanks, Amanda!

Axelrod, continued

happily carrying lunch for a young assistant professor—just had to be recorded. You see, at that time, my research was all about the ecology of herbaceous plants along the California strand, and Ax had great contempt for weak, non-woody plants that left no fossils. "Ground trash!" he called herbs disparagingly. He made no bones about telling me that I was wasting my time on the beach, when I could be studying forests. But here he was, taking a leisurely day, acting the perfect host. Come to think of it, he might have had some strategy in mind...because, on reflection, I have to admit that the research my students and I have been doing in the Sierra Nevada for the last 20 years largely is based on his suggestions.

Thank you for being a part of our lives, Daniel Isaac Axelrod.

–Michael Barbour

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